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USING MOBILE PHONES IN SUPPORT OF STUDENT LEARNING IN SECONDARY SCIENCE INQUIRY CLASSROOMS

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Abstract

This paper reports on findings from a research project concerned with how electronic networking tools (e-networked tools), such as the Internet, online forums, and mobile technologies, can support authentic science inquiry in junior secondary classrooms. It focuses on three qualitative case studies involving science teachers from two high schools together with their Year 9 and Year 10 classes. The ways teachers and students view and take up the affordances of mobile phones to support authentic science inquiry are of interest. Data were collected from teacher reflections, student interviews, a student survey, classroom observations and student work. The findings highlight three key themes that illustrate the advantage of using mobile phones as part of the classroom culture to video record group practical investigations, support students' developing abilities to think like a scientist, and enable the sharing of learning beyond the classroom. The findings have implications for practice and can contribute to a better understanding of the ways mobile devices can support and extend science inquiry in New Zealand secondary classrooms.

Keywords

Science education; inquiry learning; mobile phones; junior high; secondary classroom

Introduction

Teaching science can be challenging, particularly if it involves the incorporation of inquiry approaches (Hayes, 2002). Collaboration and co-construction of ideas and understandings requires the changing of teaching and learning practices to allow students to learn how to collaborate 'inquiry style'. It has been argued that information and communication technology (ICT), specifically e-networked tools, such as the Internet, online discussion forums and mobile devices, support and enhance inquiry learning processes by increasing levels of motivation (Song, 2014) or sustaining interest; for example, by including student owned mobile devices (Looi, Sun & Xie, 2015). Research into technology-enhanced networking is rapidly pointing at the opportunities for student participation and collaboration in the learning process, but also highlights that more theoretical-empirical underpinned work is needed to understand the drivers and products of such engagements (Resta & Laferrière, 2007; Zydney & Warner, 2016).

With an interest in inquiry learning we draw on a definition by the National Research Council (2000) stating that inquiry learning includes "the teaching and learning strategies that enable scientific concepts to be mastered through investigations" (p. xv). A key to successful inquiry is to include opportunities for students to have authentic learning experiences where they have opportunities to create new meaning and understanding. 'Authentic' learning focuses "on real-world, complex problems and their solutions" where students can utilise learning strategies including "using role-playing exercises, problem-based activities, case studies, and participation in virtual communities of practice" (Lombardi, 2007, p. 2). Being able to utilise e-networked technology to collect, analyse, access information and data, and examine ambiguities (Colwell, Hunt-Barron, & Reinking, 2013) holds much potential for inquiry learning; however, this requires that teachers and students are aware of the affordances that such technology provides.

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Mobile devices for e-networking

In this paper we refer to e-networks as a variety of electronic devices and systems that can be used to connect different actors (students and teachers) by using the Internet, including mobile-based tools, such as emails, blogs and online forums, to access, communicate and exchange information. These tools allow students to exercise agency (i.e., students taking ownership for their learning in accessing and selecting information, and even in creating their own content) (Kearney, Schuck, Burden, & Aubusson, 2012; Morgan, Williamson, Lee, & Facer, 2007). The focus of this paper is on how the use of mobile phones in class may support science inquiry in a secondary school context in order to identify pedagogical strategies that take note of the strengths and weaknesses in integrating such technology.

Research on the affordances of mobile phones in school contexts include possibilities to enable students to easily create video/audio, take photographs, integrate multimodal content, geotag, utilise text messaging, access social networking sites for communication, and distribute content to classmates, teachers and wider audiences (Crompton, Burke, Gregory, & Gräbe, 2016; Song, 2016; Vavoula, Sharples, Rudman, Meek, & Lonsdale, 2009). However, the use of mobile phones at school is also a matter of cultural appropriation, that is, there is a need to consider how socio-cultural structures, practices and the agency of media users/learners are connected (Pachler, Cook, & Bachmair, 2010). The reality is that at the school level, despite its potential, mobile phones are still only half-accepted at schools. Mobile phones are often banned or allowed only under strict conditions, since they are often perceived to be disruptive (Sharples, 2002) and therefore seldom form any formal part of teaching plans (Hartnell-Young & Heym, 2008). This presents questions on the legitimacy of mobile phone use in education and, in this specific case, inquiry learning in science.

In this paper we report on the findings of a study that aimed to uncover the ways teachers and students take up the use of mobile phones in support of science inquiry teaching and learning in three secondary classrooms. We were interested in what Tobias Roehl describes as questions of 'mediality'—or the ways that students are engaged by different material objects in the classroom; and 'performativity'— the ways students are performed by material objects, meaning what kind of student-subject emerges in the engagement with the material object (Roehl, 2012, p. 54). These ideas underpin our assumptions that mobile phone use in New Zealand secondary high schools may support student agency and ownership in the pursuit of authentic learning experiences.

The NILLS project

The study reported in this paper was part of a wider two-year funded research project—Networked Inquiry Learning in Secondary Science classrooms (NILSS)—that investigated the extent e-networked tools can support authentic science inquiry in junior secondary classrooms in order to address concerns about student engagement in science (Williams, et al., 2013). The research question of interest was: How does mobile phone use impact on inquiry learning in science classrooms?

Data were drawn from the cases of three teachers (D, M and J) and that of their students, which constituted two Year 9 classes (13-year-olds) and one Year 10 class (14-year-olds). To explain the context of the three cases we start with Teacher M, who is an experienced teacher and heads the junior science specialist programme where she also oversees staff professional development in the school on inquiry learning. In our project she taught one of the Year 9 classes. Her colleague, Teacher J, worked at the same school and also taught a Year 9 class. Teacher D taught a Year 10 class at a different school and was at the time in his fifth year of teaching junior science and senior physics classes. The schools that were involved generally had a no-mobile-phone-during-class-time policy; however, the teachers had the liberty to allow for mobile phone usage in their classes at their discretion. All three teachers generally had different expertise and comfort levels with incorporating technology in their classrooms. Both schools were located in major suburban areas in the central Waikato and Bay of Plenty regions in Aotearoa New Zealand. The study obtained ethical approval from the Faculty of Education Human Ethics Committee at the University of Waikato and all participants consented to taking part in the study.

Research design

A qualitative interpretive methodology framed the collection and analysis of data. Multiple forms of data collection through teacher planning documents, classroom observations (field notes and video recordings), student work, records from networked activities (e.g., students' mobile phone video recordings), teacher reflections and insights, and student interviews evidenced the study and facilitated triangulation of data. Thematic analyses were conducted on the text-based data (Braun & Clarke, 2006). All data were analysed by the researchers separately and then collectively to identify emerging themes and patterns. Data analysis occurred in iterative cycles to inform and refine teacher practice across the two-year project.

Findings

The following three themes were identified to illustrate the use of mobile phones in science inquiries: when mobile phones are part of the classroom culture, when mobile phones help students to think like a scientist, and when mobile phones enable students to share their learning with interested others beyond the classroom. Representative classroom example(s) across the three case studies and participant quotes are provided to evidence each theme.

Theme 1: When mobile phones are part of the classroom culture

When teachers open up their classroom practices to encourage students to use their mobile phones to video record their inquiry investigations, students have opportunities to review and reflect on their experiences. However, the level as to how successful this can be is dependent on the prevailing cultural practices in regard to technologies like mobile phones. The first example is taken from Teacher D's Year 10 class. The focus of the science inquiry unit for the term was water pollution and water quality. In Teacher D's class it was already part of his established classroom culture for students to use their personal mobile phones to record and share their learning with each other as well as with the teacher. The teacher would then in turn share students' learning with the wider class. Mobile phone usage in this example was student initiated. Teacher D explains,

> When we do our [lab] practicals, I'm quite happy for them to take their cameras out or their phones to record it all. It's just nice knowing that they want to record it on their cells [mobiles] and they are using the technologies on their cells to record it, so they are going the next step … I'm certainly not going to stop them. (Teacher D)

In this particular example, students were involved in a practical group investigation to observe the effects of combining milk, food colouring and liquid detergent. The learning objective was to investigate how different compounds affect the water's surface tension.

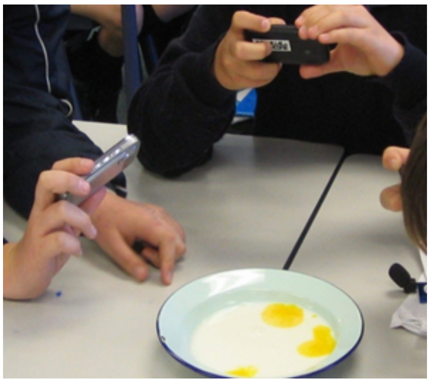

Figure 1: Student initiated mobile phone use in practical science investigations.

The conversations amongst students of one particular group showed how they used their mobile phones to video record and then review the experiment immediately after. They did this several times during their inquiry, each time asking new questions and postulating possible relationships between ideas. Each new (repeated) video recording represented a new question or possible angle of questioning by group members, which led them to pursue new and further investigations.

> Did someone put detergent in … do a different area, in the middle now … let me do it … did you see that … let it come back … awesome … that was amazing I don't understand what it is it just pushes it away … let's take pictures … you make yellow and green … don't stir it just put a drop in, I want to do this at home … try doing a bit of both with the milk and a couple of colours and then with detergent … (student group discussion)

By watching and reviewing their own footage, the students expanded on their inquiry. The recorded observations gave rise to new questions of interest leading them to explore what they had observed further.

Figure 2: A detailed video recording captured on a student's mobile phone.

A different scenario was observed in Teacher J's Year 9 class. The focus of the inquiry unit was on chemical changes, chemical reactions and practical investigations. Mobile phone use was not common practice in his classroom, but in this particular instance the researchers suggested to Teacher J to try it out. Teacher J took up this suggestion and allowed his students to use their phone to record and review lab-based experiments, and take note of observations. After the class, interviews with students highlight their somewhat limited view on the potential of mobile phones to support their learning. When asked about their use of mobile phones in class, students responded that their reason for doing so was motivated by the teacher requesting them to do so: "Because Mr J asked us to." When asked what they thought the advantage of using their phones in class was, students explained they could see the potential for recording their investigations and to "see where we had done wrong". In this example, it became evident that the students were unsure about their purpose for learning and jumped to the conclusion that it could be mainly for assessing and troubleshooting their own mistakes.

Theme 2: When mobile phones help students to think like a scientist

When teachers encourage their students to use mobile phones to record and document a scientific process through videos, the reviewing and reporting of such data can support students to 'think aloud' like a scientist (i.e., by using scientific vocabulary to explain the process, review and reflect on process). In this example drawn from Teacher M's Year 9 class, students were working on an inquiry unit on 'kitchen' chemistry. Teacher M's goal was to enhance students' chemistry literacy on key terms and concepts, consider steps in a chemical change of state process, and develop student autonomy for their own learning. As with Teacher D's example, mobile phones were frequently used in Teacher M's class together with other e-networked tools (online forums) and standalone technologies, such as digital cameras and video recorders. The students initiated video recordings of their practical investigation on fudge making. The students narrated what they were doing or seeing while filming, thus providing opportunities to use key terms and concepts they had been introduced to.

Students were asked to review their phone recordings in the next lesson to complete an assessment activity on key terminologies used in the fudge making process.

Figure 3: Student narration and recording of the fudge making process.

Mobile phone video recordings supported scientific ways of observation and reflection and that helped the students to explore, explain, support and evaluate their ideas. Student narrations exemplified their developing understanding of key terms and observation of the process; for example, "heating and stirring until the mixture bubbles … bubbling is a sign that things are dissolving". Teacher M reflected on the explicit use of mobile phones in supporting students' learning and being reflective of the process:

> It [mobile phone photo and video recordings] will be helpful for their reflection. I want to try to get copies of it all on my machine. They can just play it back and listen. Two groups were really good in terms of the commentary going in. That will be quite good to just to listen to. It was again a good learning process. (Teacher M)

Figure 4: Students reviewing their group practical investigation and listening to their own narration.

Used this way, mobile phone video recordings can be a diagnostic, formative assessment tool that promotes student self-reflection on their thinking when they are discussing their scientific experiences and reflecting on the meaning they can make from these experiences.

Theme 3: When mobile phones enable sharing beyond the classroom

Using mobile phones to video record their inquiry investigations enables students to share their learning with those interested in their learning beyond their classroom boundaries. In this final theme, examples were drawn from both Teacher D and M's classes where mobile phone use is an accepted learning tool. Both teachers observed that some students would share their learning of the day with the wider community interested in their progress—parents, extended family, and friends outside of school. We observed a student taking a photo of an observation made under the microscope. When we asked her why she took the photo she explained that she wanted to show it to her mother. Tapping into an authentic audience through their own devices about things they were interested or excited about supported their ongoing interest and engagement with science issues. Teacher D noted:

> A few [students] will probably go onto Facebook tonight and probably post it on Facebook. For them they think it's a cool buzz. They take it home and they show their mums and dads, 'this is what we've actually done in school'. (Teacher D)

This, in turn, enriched students' developing science understandings by expanding conversations within and beyond the classroom. A representative student quote: "It helps a lot if you are watching a [mobile phone] video, you take it in more … and you remember it better" (Student from Teacher D's class).

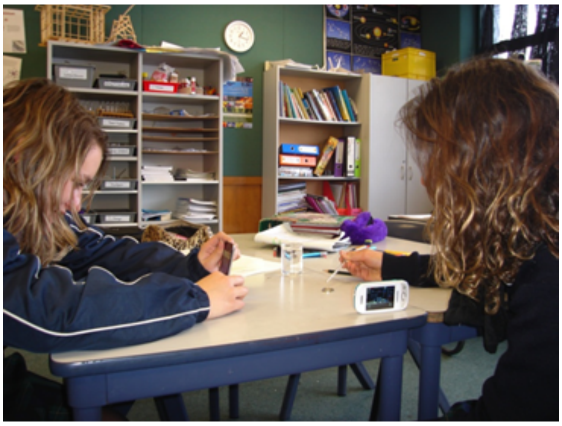

Figure 5: Two students using their mobile phones, each video-recording various stages of science investigations for subsequent sharing with a wider audience.

Teacher M added to this that her students' mobile phone video recordings of the fudge making process, which included students' running commentary/narration, were uploaded to YouTube to serve as a shared learning record for junior students. She saw this as a new and additional form of evidence of student learning as well as a record of the science content that was of interest and had been observed by students.

> A couple of them [students] have already videoed stuff going on throughout the year and thrown them up on YouTube. They are quite tech savvy … Kids definitely looked at it [kitchen chemistry] from a scientist point of view rather than as a food tech unit. (Teacher M)

Teacher M's students explained to us the benefit of being able to record their learning as a reference for others interested in their work (juniors and wider audience) as a new and powerful way of learning:

> We are videoing and explaining what is happening with the fudge so we can look back and see and hear what is happening. You can see it. It explains it more in terms of happening. We are going to put it up on YouTube. The teacher puts it up on the YouTube for the next class. It's a different way of learning. (Student from Teacher M's class)

This section has highlighted three key themes involving ways teachers and their students have tapped into the mobile phone's affordances to support different aspects of science inquiry investigations and learning. We found that if aligned with classroom practices to do with the use of student owned technology, students were empowered to consider the capture of learning experiences, review questions and pursue new lines of investigation. This supported their scientific inquiry while being able to share their learning with those communities who matter to them.

Discussion

This study was motivated by our interest to investigate how students might be supported to engage in authentic science inquiries through e-networked tools, such as mobile phones. The findings illustrate that under particular conditions mobile phones can support science inquiry learning by increasing the opportunities for student participation and collaboration in the inquiry learning process. Students' use of mobile phones was regulated by school policies and teacher practices. This meant that the phones were only used as recording devices (photos and videos) and sharing of those recordings. Brummelhuis and Kuiper (2008) explain that the factors that shape the infusion of ICT into education are to do with the student, the teacher, the curriculum and the infrastructure whereby teachers and students' roles are defined by the amount of control, responsibility or autonomy they can exert. Mobile phones inhabit a special space in the range of technologies that can be used at school and therefore require different ways of considering their pedagogical value. Pachler et al., (2010) explain that mobile phones are better to be viewed as a part of a 'mobile complex' to illustrate the extent they are becoming widely accepted and embedded in our society today and thus "exist in a specific interrelationship with a social, cultural and economic world in transformation" (p. 2). It was very clear in our own observations that the success in using mobile phones was shaped by the socio-cultural classroom practices to do with mobile phone uptake and use.

The reported experiences of the three secondary school science teachers, and the observations of the students' use of mobile phones during practical science laboratory work, highlight the different ways that mobile phones were adopted to support and extend inquiry during science learning. Students' use of the visual recording capability on mobile phones to video record practical group investigations was valuable in helping them understand otherwise hard-to-comprehend science content. However, this was only the case for those classes where the use of mobile phones was already part of the classroom practices. The act of recording meant students could adopt a reflective stance during the activity and were provided with multimodal opportunities to expand their critical observational skills and to reflect on and talk about science. Kearney and Schuck (2006) write that incorporating the affordances that digital video offers into learning activities gives more student voice and opportunities for authentic learning since learning is "motivated and developed by the context" (p. 203). It was evident in the examples we observed that the classroom practices shaped the students' abilities to identify and act on the mobile phone's various affordances as a networking tool (Song, 2013).

In the study students reviewed their recordings, which at times prompted the pursuit of new questions and investigations, and increased student agency for their learning. Importantly, student ownership of, and control over, their phones meant they could use them in their science inquiries as and when they saw a need, reducing their need to rely on teacher or school-managed systems. In this way the devices supported students being able to exercise agency to pursue investigations of interest. Others have found that when students undertake their own investigations they take more ownership over their learning and develop the skills of how to learn (Hipkins, 2006). Furthermore, learning environments that allow for flexibility and ease in accessing mobile phones can empower and engage students, including their sense of ownership and responsibility for their own learning. Through this, students can use their network connections through their mobile phones and share their experiences beyond the confines of the classroom with their peers, family members and wider community.

These findings have implications for teacher practice. These are:

- Teachers can explore with their students what affordances mobile phones offer in support of networking with others and inquiry learning. This needs to be discussed explicitly. Student ownership of mobile phones does not equal knowing how to use them in or for science,
- Teachers can consider establishing classroom practice cultures where students use mobile phones to support inquiry investigations,

- There is value in mobile phone applications that support students to observe and review emerging ideas science ideas, and
- There is value in identifying the empowering attributes that mobile devices offer if they are used to connect with communities that matter to students' learning.

Conclusion

Throughout the world, educators are grappling with more effective strategies for preparing students to face the challenges in the twenty-first century. Our study has indicated the potential of using mobile phones as e-networked tools to support inquiry-learning processes. The study revealed aspects of mediality and perfomativity (Roehl, 2012) through how students engaged with mobile phones as material objects as well as how the networking technology affected them in shaping their engagement in class during their science inquiry. While the use of mobile phones in schools has been reported to present new pedagogical opportunities (Looi et al., 2015) we found that this was shaped by the socio-cultural conditions of technology use. The continuing forecasts of technology infusion in schools places high expectations internationally (Johnson et al., 2014) including in Aotearoa New Zealand to explore and adopt more open and collaborative e-networked technology pedagogies through school policies that allow for mobile phone uses. This study has illustrated an Aotearoa New Zealand example of the uses of mobile phones in inquiry learning in science. It is hoped that the findings will contribute to furthering dialogue and practice in support of the present twenty-first century (and future) digital learner and classrooms.

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